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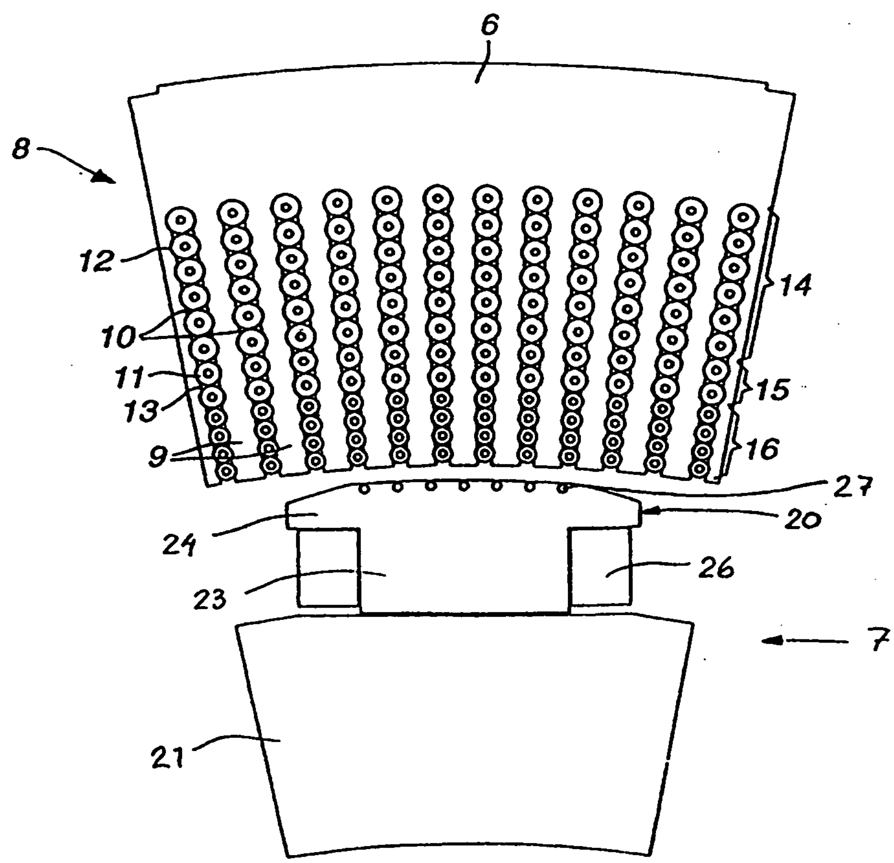
(54) Title: ROTATING ELECTRIC MACHINE FOR HIGH VOLTAGE

(57) Abstract

The present invention relates to a rotating electric high voltage machine comprising a stator (8), a rotor (7; 37; 47) and at least one winding. The machine is characterized in that said winding comprises at least one current-carrying conductor (2), that a first layer (3) having semiconducting properties is provided around said conductor, that a solid insulating layer (4) is provided around said first layer, and that a second layer (5) having semiconducting properties is provided around said insulating layer. Alternatively, the rotating electric machine according to the invention is provided with a magnetic circuit for high voltage comprising a magnetic core and a winding, and is characterized in that said winding is formed of a cable (1; 11) comprising at least one current-carrying conductor (2), that each conductor comprises a number of strands (18), that an inner semiconducting layer (3) is provided around each conductor, that an insulating layer (4) of solid insulating material is provided around said inner semiconducting layer, and that an outer semiconducting layer (5) is provided around said insulating layer.



Rotating electric machine for high voltage

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a rotating electric machine in accordance with the introductory part of claim 1 and a rotating electric machine in accordance with the introductory part of claim 9.

The rotating electric machines which are referred to in this context comprise synchronous machines which are substantially used as generators for connection to distribution and transmission networks, commonly referred to below as power networks. Synchronous machines are also used as motors and for phase compensation and voltage control, in that case as mechanically idling machines. The technical field also comprises asynchronous machines, double-fed machines, alternating current machines, asynchronous converter cascades, external pole machines and synchronous flux machines.

The magnetic circuit referred to in this context comprises a magnetic core of laminated, non-oriented or oriented, sheet or other material, for example amorphous or powder-based, or any other arrangement for the purpose of allowing an alternating magnetic flux, a winding, a cooling system, etc., and which may be arranged in the stator of the machine, in the rotor or in both.

BACKGROUND OF THE INVENTION

In order to explain and describe the machine, a brief description of a rotating electric machine will first be given, exemplified on the basis of a synchronous machine. The first part of the description substantially relates to the magnetic circuit of such a machine and how it is composed according to conventional technique. Since the magnetic circuit referred to in most cases is arranged in the stator, the magnetic circuit below will normally be described as a

stator with a laminated core, the winding of which will be referred to as a stator winding, and the slots in the laminated core for the winding will be referred to as stator slots or simply slots.

Most synchronous machines have a field winding in the rotor, where the main flux is generated by direct current, and an A.C. winding in the stator. Synchronous machines are normally of three-phase design and the invention substantially relates to such machines. Sometimes, synchronous machines are designed with salient poles. However, cylindrical rotors are used for two- or four-pole turbogenerators and for double-fed machines. The latter have an A.C. winding in the rotor.

The stator body for large synchronous machines are often made of sheet steel with a welded construction. The laminated core is normally made from lacquered 0.35 or 0.5 mm electrical steel sheet. For radial ventilation and cooling, the laminated core, at least for medium-large and large machines, is divided into stacks with radial and axial ventilation channels. For larger machines, the sheet is punched into segments which are attached to the stator body by means of wedges/dovetails. The laminated core is retained by pressure fingers and pressure plates. The stator winding is disposed in slots in the laminated core where the slots normally have a cross section in the form of a rectangle or a trapezoid.

Polyphase A.C. windings are designed either as single-layer or two-layer windings. In the case of single-layer windings, there is only one coil side per slot, and in the case of two-layer windings there are two coil sides per slot. By coil side is meant one or more conductors brought together in height and/or width and provided with a common coil insulation, i.e. an insulation intended to withstand the rated (test) voltage towards ground. Two-layer windings are usually designed as diamond windings, whereas the single-layer windings which are

relevant in this connection may be designed as a diamond winding or as a concentric winding. In the case of a diamond winding, only one coil span (or possibly two coil spans) occurs, whereas flat windings are designed as concentric windings, i.e. with a greatly varying coil span. By coil span is meant the distance in arc measure between two coil sides belonging to the same coil, either in relation to the relevant pole pitch or in the number of intermediate slot pitches. Usually, different variants of cording are used, for example fractional pitch, to give the winding the desired properties.

The type of winding substantially describes how the coils in the slots, i.e. the coil sides, are connected together outside the stator, i.e. at the coil ends. A typical coil side is formed from so-called Roebel bars, wherein certain bars have been made hollow for a coolant. A Roebel bar comprises a plurality of rectangular, parallel-connected copper conductors, which are transposed 360 degrees along the slot. Ringland bars with transpositions of 540 degrees and other transpositions also occur. The transposition is necessary to avoid circulating currents. Between each strand there is a thin insulation, for example epoxy/glass fibre. The main insulation between the slots and the conductors is made, for example, of epoxy/glass fibre/mica and has at its outermost end a thin semiconducting ground-potential layer which is used to equalize the electric field. Outside the sheet stack of the stator, on the other hand, there is no external semiconducting ground-potential layer, but an electric field control in the form of so-called corona protection varnish intended to convert a radial field into an axial field, which means that the insulation on the coil ends occurs at a high potential relative to ground. The field control is a problem which sometimes gives rise to corona in the coil-end region, which may be destructive.

Normally, all large machines are designed with a two-layer winding and equally large coils. Each coil is placed with one side in one of the layers and the other side in the other layer. This means that all the coils cross each other in the coil end. If more than two layers are used, these crossings render the winding work difficult and deteriorate the coil end.

What is mentioned above can be said to be part of conventional technique relating to current rotating electric machines.

During the last decades, there have been increasing demands for rotating electric machines with higher voltages than what has previously been possible to design. The maximum voltage level which, according to the state of the art, has been possible to achieve for synchronous machines with a good yield in the coil production is around 25-30 kV. It is also commonly known that the connection of a synchronous machine/generator to a power network must take place via a Δ/Y-connected so-called step-up transformer, since the voltage of the power network normally lies at a higher level than the voltage of the rotating electric machine. Thus, this transformer, and the synchronous machine, constitute integral parts of an installation. The transformer constitutes an extra cost and also has the disadvantage that the total efficiency of the system is reduced. If it were possible to manufacture machines with considerably higher voltages, the step-up transformer could thus be omitted.

Attempts to develop the generator with higher voltages have, however, been in progress for a long time. This is obvious, for instance from "Electrical World", October 15, 1932, pages 524-525. This describes how a generator designed by Parson 1929 was arranged for 33 kV. It also describes a generator in Langerbrugge, Belgium, which produced a voltage of 36 kV. Although the article also speculates on the possibility of

increasing voltage levels still further, the development was curtailed by the concepts upon which these generators were based. This was primarily because of the shortcomings of the insulation system where varnish-impregnated layers of mica oil and paper were used in several separate layers.

Certain attempts at new approach as regards the design of synchronous machines are described, inter alia, in an article entitled "Water-and-oil-cooled Turbogenerator TVM-300" in J. Elektrotechnika, No. 1, 1970, pp. 6-8, in US 4,429,244 "Stator of Generator" and in Russian patent document CCCP Patent 955369.

The water- and oil-cooled synchronous machine described in J. Elektrotechnika is intended for voltages up to 20 kV. The article describes a new insulation system consisting of oil/paper insulation, which makes it possible to immerse the stator completely in oil. The oil can then be used as a coolant while at the same time using it as insulation. To prevent oil in the stator from leaking out towards the rotor, a dielectric oil-separating ring is provided at the internal surface of the core. The stator winding is made from conductors with an oval hollow shape provided with oil and paper insulation. The coil sides with their insulation are secured to the slots, made with rectangular cross section, by means of wedges. As coolant, oil is used both in the hollow conductors and in holes in the stator walls. Such cooling systems, however, entail a large number of connections for both oil and electricity at the coil ends. The thick insulation also entails an increased radius of curvature of the conductors, which in turn results in an increased size of the winding overhang.

The above-mentioned US patent relates to the stator part of a synchronous machine which comprises a magnetic core of laminated sheet with trapezoidal slots for the stator winding. The

slots are tapered since the need for insulation of the stator winding is less towards the interior of the rotor where that part of the winding which is located nearest the neutral point is disposed. In addition, the stator part comprises a dielectric oil-separating cylinder or ring nearest the inner surface of the core which may increase the magnetization requirement relative to a machine without this ring. The stator winding is made of oil-immersed cables with the same diameter for each coil layer. The layers are separated from each other by means of spacers in the slots and secured by wedges. What is special for the winding is that it comprises two so-called half-windings connected in series. One of the two half-windings is disposed, centred, inside an insulation sleeve. The conductors of the stator winding are cooled by surrounding oil. The disadvantages with such a large quantity of oil in the system are the risk of leakage and the considerable amount of cleaning work which may result from a fault condition. Those parts of the insulation sleeve which are located outside the slots have a cylindrical part and a conical termination reinforced with current-carrying layers, the purpose of which is to control the electric field strength in the region where the cable enters the end winding.

From CCCP 955369 it is clear, in another attempt to raise the rated voltage of the synchronous machine, that the oil-cooled stator winding comprises a conventional high-voltage cable with the same dimension for all the layers. The cable is placed in stator slots formed as circular, radially disposed openings corresponding to the cross-section area of the cable and with the necessary space for fixation and for coolant. The different radially disposed layers of the winding are surrounded by and fixed in insulated tubes. Insulating spacers fix the tubes in the stator slot. Because of the oil cooling, an internal dielectric ring is also needed here for sealing the coolant against the internal air gap. The design shown shows no tapering of the insulation or of the stator slots.

The design exhibits a very narrow radial waist between the different stator slots, which means a large slot leakage flux which significantly influences the magnetization requirement of the machine.

In machine designs according to the documents described above, the electromagnetic material in the stator is not optimally utilized. From a magnetic point of view, the stator ends shall connect as closely as possible with the casing of the coil sides. It is most desirable to have a stator tooth with a maximum width at each level, since the width of the tooth significantly influences the losses and the magnetization requirement of the machine. This is especially important for machines for higher voltage since the number of conductors per slot there becomes large.

With reference to a report from the Electric Power Research Institute, EPRI, EL-3391 from April 1984, an account is given of generator concepts for achieving higher voltage in an electric generator with the object of being able to connect such a generator to a power network without intermediate transformers. Such a solution is assessed in the report as offering good gains in efficiency and considerable financial advantages. The main reason that it was deemed possible in 1984 to start developing generators for direct connection to power networks was that a supra-conducting rotor had been developed at that time. The considerable excitation capacity of the supra-conducting field enables the use of airgap-winding with sufficient thickness to withstand the electrical stresses.

By combining the concept deemed most promising according to the project, that of designing a magnetic circuit with winding, known as "monolith cylinder armature", a concept in which two cylinders of conductors are enclosed in three cylinders of insulation and the whole structure is attached to

an iron core without teeth, it was assessed that a rotating electric machine for high voltage could be directly connected to a power network. The solution entailed the main insulation having to be made sufficiently thick to withstand network-to-network and network-to-earth potentials. Obvious drawbacks with the proposed solution, besides its demand for a supra-conducting rotor, are that it also requires extremely thick insulation, which increases the machine size. The coil ends must be insulated and cooled with oil or freons in order to control the large electric fields at the ends. The whole machine must be hermetically enclosed in order to prevent the liquid dielectric medium from absorbing moisture from the atmosphere.

SUMMARY OF THE INVENTION

The object of the present invention is to solve the above mentioned problems and to provide a rotating electric machine which permits direct connection to all types of high-voltage power networks. This object is achieved by providing the machine defined in the introductory part of claim 1 with the advantageous features of the characterizing part of said claim.

Accordingly, the winding comprises at least one current-carrying conductor and the machine is further characterized in that a first layer having semiconducting properties is provided around said conductor, that a solid insulating layer is provided around said first layer, and that a second layer having semiconducting properties is provided around said insulating layer.

A very important advantage of the present invention, as defined in claim 1, is that the use of the described insulated conductor for the winding makes it possible to obtain a rotating electric machine with a considerably higher voltage than machines according to the state of the art. In fact, a

rotating electric machine as defined in claim 1 has the advantage that it is possible to have at least one winding system of conductors suitable for direct connection to distribution or transmission networks. Consequently, the voltage level in question is 36 kV - 800 kV, and preferably 72,5 kV - 800 kV.

This also entails the further important advantage that the Δ/Y-connected step-up transformer mentioned above can be omitted. Consequently, the solution according to the present invention represents major savings both in economic terms and regarding space requirement and weight for generator plants and other installations comprising rotating electric machines.

In order to cope with the problems which arise in the case of direct connection of rotating electric machines to all types of high-voltage power networks, a machine according to the invention may have a number of features which significantly distinguishes it from the state of the art both as regards conventional mechanical engineering and the mechanical engineering which has been published during the last few years. Some features will follow below.

As mentioned, the winding is manufactured from one or more insulated conductors with an inner and an outer semiconducting layer, preferably an extruded cable of some sort. Some typical examples of such conductors are a cable of crosslinked polyethylene (XLPE) or a cable with ethylene propylene (EP) rubber insulation, which, however, for this purpose and according to the invention, has an improved design both as regards the strands of the conductor and as regards the outer layer.

The use of an insulated conductor with an outer semiconducting layer has the advantage that it permits the outer layer of the winding, in its full length, to be maintained at ground

potential. Consequently, the claimed invention may have the feature that the outer semiconducting layer is connected to ground potential. As an alternative, the outer layer may be cut off, at suitable locations along the length of the conductor, and each cut-off part length may be directly connected to ground potential.

A considerable advantage with having the outer layer connected to ground potential is that the electric field will be near zero in the coil-end region outside the outer semiconductor and that the electric field need not be controlled. This implies that no field concentrations can be obtained within the sheet, in the coil-end region, or in the transition therebetween.

As another advantageous feature at least two, and preferably all three, of the layers have substantially equal thermal expansion coefficients. Through this is achieved that thermal movement is prevented and the occurrence of cracks, fissures or other defects in the winding due to thermal movement is avoided.

According to another characterizing feature each of the three layers is solidly connected to the adjacent layer along substantially the whole connecting surface. This has the advantage that the layers are fixed and unable to move in relation to each other and serves to ensure that no play occurs between the layers. It is very important that no air is allowed to enter in-between the layers since that would lead to disturbances in the electric field.

As yet another advantageous feature the present invention is characterized in that the current-carrying conductor comprises a number of strands, only a minority of said strands being uninsulated from each other. The uninsulated strand or strands in the outer layer of the conductor defines the potential on

the inner semiconducting layer and thereby ensures a uniform electric field within the insulation. By using uninsulated strands instead of insulated strands a less expensive insulated conductor for a winding is obtained. Theoretically, every second strand may be uninsulated, but for practical reasons the number of uninsulated strands is less than the insulated strands.

As an alternative, the object may be achieved by providing the machine defined in the introductory part of claim 9 with the advantageous features of the characterizing part of said claim. Accordingly, the winding is formed of a cable comprising at least one current-carrying conductor and the machine is further characterized in that each conductor comprises a number of strands, that an inner semiconducting layer is provided around each conductor, that an insulating layer of solid insulating material is provided around said inner semiconducting layer, and that an outer semiconducting layer is provided around said insulating layer.

Naturally, the cable according to claim 9 may be provided with any one of the features of claims 2-8 regarding the winding.

Preferably, cables with a circular cross section are used. However, in order to obtain, among other things, better packing density, cables with a different cross section may be used.

The use of an insulated conductor or cable according to the invention has the additional advantage that it permits the laminated core, both with respect to slots and teeth, to be designed in a new and optimal way.

As a further advantageous feature, the winding may be designed with tapered insulation to utilize the laminated core in the best way.

To continue, the shape of the slots may advantageously be adapted to the cross section of the cable of the winding in such a way that the slots are formed as a number of cylindrical openings, extending axially and radially outside one another, with a substantially circular cross section, and with an open waist extending between the layers of the stator winding. The shape of the slots may also be adapted to the tapered insulation of the winding. As an additional feature, the substantially circular cross section may, counting from the ridge portion of the laminated core, be designed with a continuously decreasing radius, or, as an alternative, with a discontinuously decreasing radius.

A particular advantage with the tapered insulation is that a reasonably constant tooth width can be obtained, independently of the radial extension.

Furthermore, the winding is preferably designed as a multi-layer concentric cable winding to reduce the number of coil-end crossings.

As a further feature, the machine according to the invention may be characterized in that the cable also comprises a metal shield and a sheath.

The rotor of the rotating electric machine according to the present invention may be designed in a number of different ways, known per se. In brief it may be mentioned that the rotor may be a rotor comprising salient poles and including a number of different features related to that configuration. For example, it may be designed with or without a damper winding, with or without an armature spider.

Alternatively, the rotor may be a turbo type rotor and include a number of different features related to that particular

configuration. For example, it may be designed with or without grooves for a cooling medium, with or without ventilation ducts.

As yet an alternative, the rotor may be configured as a cylindric rotor and, naturally, include a number of different features related to such a configuration. For example, it may be designed with or without a damper winding, with or without an armature spider, with or without a shaft, with or without bearings. In general, as applicable, the winding may be made of copper strips, it may be a single-phase or three-phase winding, it may be a diamond winding, a bar winding, a flat winding or a squirrel cage winding, etc.

The rotor may further be designed for horizontal or vertical mounting, it may be provided with slip rings, it may be provided with a brushless exciter etc. The rotor may also be made of different materials. Other configurations and features are also possible.

Further features and advantages will be apparent from the remaining dependent claims.

As a summary, thus, a rotating electric machine according to the invention results in a considerable number of important advantages in relation to corresponding prior art machines. First of all, it can be connected directly to a power network at all types of high voltage. Another important advantage is that ground potential may be consistently provided along the whole winding, which implies that the coil-end region can be made compact and that bracing means at the coil-end region can be applied at practically ground potential. Still another important advantage is that oil-based insulation and cooling systems will disappear. This means that no sealing problems will arise and that the dielectric ring previously mentioned is not needed. Another important feature is that all forced

ventilation can be made at ground potential. In addition, a considerable space and weight saving from the installation point of view is obtained with a rotating electric machine according to the invention, since it replaces a previous installation design with both a machine and a step-up transformer.

BRIEF DESCRIPTION OF THE DRAWINGS

- Figure 1 is a detailed perspective view of an insulated conductor or cable according to the present invention,
- Figure 2 shows a schematic axial end view of a sector/pole pitch of a magnetic circuit according to one embodiment of the invention,
- Figure 3 shows a schematic axial end view of a sector/pole pitch of a magnetic circuit according to another embodiment of the invention, and
- Figure 4 shows a schematic axial end view of a part of a sector/pole pitch of a magnetic circuit according to yet another embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

An important condition for being able to manufacture a rotating electric machine in accordance with the disclosure of the invention is to use, for the winding, an insulated conductor or a conductor cable with an electrical insulation with a semiconducting layer both at the conductor and at the casing. Such cables are available as standard cables for other power engineering fields of use. As described under the summary of the invention, however, an improved embodiment of such a standard cable is preferably used as a stator winding.

In order to describe an embodiment, initially a short description of a standard cable will be made. The internal current-carrying conductor comprises a number of uninsulated strands. Around the strands there is a semiconducting inner layer. Around this semiconducting inner layer, there is an

insulating layer of extruded insulation. An example of such an extruded insulation is XLPE or, alternatively, so-called EP rubber. This insulating layer is surrounded by an external semiconducting layer which, in turn, is surrounded by a metal shield and a sheath. Such a cable will be referred to below as a power cable.

A preferred embodiment of the improved cable or insulated conductor is shown in Figure 1. The insulated conductor or cable 1 is represented in the figure as comprising a current-carrying conductor 2 which comprises a number of strands 18. The strands are transposed both uninsulated and insulated strands. Transposed, insulated strands are also possible. Around the conductor there is an inner semiconducting layer 3 which, in turn, is surrounded by an extruded insulation layer 4. This layer is surrounded by an external semiconducting layer or layer 5. The cable used as a winding in the preferred embodiment has no metal shield and no external sheath. In order to avoid induced currents and losses, the external semiconducting layer has such a high resistivity that the induced voltage does not provoke any appreciable losses. As an alternative to avoid induced currents and losses associated therewith in the outer semiconductor, this is cut off, preferably in the coil end, i.e. in the transitions from the sheet stack to the end windings. Each cut-off part is then connected to ground, whereby the external semiconductor will be maintained at, or near, ground potential for the whole cable length. This means that, around the extruded insulated winding at the coil ends, the contactable surfaces, and the surfaces which are dirty after some time of use, only have negligible potentials to ground, and that they also cause negligible electric fields.

As regards the geometric dimensions of the insulated conductor or cable the conductor area is comprised in the approximate

interval of 80 - 3000 mm^2 and the outer diameter is in the approximate interval of 20 - 250mm.

To optimize a rotating electric machine, the design of the magnetic circuit as regards the slots and the teeth, respectively, are of decisive importance. As mentioned above, the slots should connect as closely as possible to the casing of the coil sides. It is also desirable that the teeth at each radial level are as wide as possible. This is important to minimize the losses, the magnetization requirement, etc., of the machine.

With access to the above described insulated conductor or cable for the winding, there are great possibilities of being able to optimize the laminated core from the above mentioned points of view. In the following, a magnetic circuit in the stator of the rotating electric machine is referred to. Figure 2 shows an axial end view of a sector/pole pitch 6 of a magnetic circuit according to one embodiment of the invention, namely an embodiment including a rotor 7 with salient poles 20. In a conventional manner, the stator is composed of a laminated core of electric sheets successively composed of sector-shaped sheets. From a rear portion of the stator core 8, located at the radially outermost end, a number of teeth 9 extend radially inwards towards the rotor. Between the teeth there are a corresponding number of slots 10. The slots have a cross section tapering towards the rotor, since the need for cable insulation decreases for each winding layer in the direction towards the air gap. As is clear from the figure, the slot substantially consists of a circular cross section 12 around each layer of the winding with narrower waist portions 13 between the layers. With a certain justification, such a slot cross section may be referred to as a "bicycle chain slot". However, it need not be symmetric. In a high-voltage machine, a relatively large number of layers will be needed and, if a continuous tapering of the cable insulation and the

stator slot, respectively, is desired, a large number of cable dimensions are required. However, it will neither be practical nor economic to use more than a certain number of cable dimensions. Therefore, as shown in the embodiment of Figure 2, cables 11 with three different dimensions of the cable insulation are used, arranged in three correspondingly dimensioned sections 14, 15 and 16, i.e. in practice a modified bicycle chain slot is obtained. The rotor 7 represented in Figure 2, which is only partly shown, is as mentioned a rotor with salient poles 20. It comprises a rotor rim 21, a pole body 23 with a pole plate 24 and a field winding 26. The illustrated pole is also provided with a damper winding 27.

Figure 3 shows a schematic axial end view of a sector/pole pitch of a magnetic circuit according to another embodiment of the invention, namely an embodiment including a turbo type rotor 37, only partly shown. The different parts of the stator and the stator winding are essentially the same as in figure 2 and have accordingly been given the same reference numerals. The rotor includes a body and a shaft 32 forged from solid steel. It is provided with milled slots 35 for the rotor winding 36. The represented turbo rotor is also provided with poles 30.

Figure 4 shows a schematic axial end view of a part of a sector/pole pitch of a magnetic circuit according to yet another embodiment of the invention, namely an embodiment including a cylindric rotor 47, only partly shown. The illustrated rotor is a laminated rotor with a regular field winding. The rotor includes a shaft 42 and a rotor rim 41 provided with slots 45 for the rotor winding 46. The rotor is also provided with poles 40.

As an alternative, the cable which is used as a winding may be a conventional power cable, like the one described above. The

grounding of the external semiconducting shield then takes place by stripping the cable of the metal shield and the sheath at suitable locations.

It should be noted that the scope of the invention accommodates a large number of alternative embodiments of a modified cycle chain slot, depending on the available insulated conductor or cable dimensions as far as insulation and the external semiconductor layer etc. are concerned.

As winding, a winding is preferably used which may be described as a multilayer, concentric cable winding. Such a winding implies that the number of crossings at the coil ends has been minimized by placing all the coils within the same group radially outside one another. This also permits a simpler method for the manufacture and the threading of the stator winding in the different slots.

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Patent claims

1. A rotating electric high voltage machine comprising a stator (8), a rotor (7;37;47) and at least one winding, **characterized** in that said winding comprises at least one current-carrying conductor (2), that a first layer (3) having semiconducting properties is provided around said conductor, that a solid insulating layer (4) is provided around said first layer, and that a second layer (5) having semiconducting properties is provided around said insulating layer.

2. A rotating machine according to claim 1, **characterized** in that the potential of said first layer is substantially equal to the potential of the conductor.

3. A rotating machine according to claim 1 or 2, **characterized** in that said second layer is arranged to constitute a substantially equipotential surface surrounding said conductor.

4. A rotating machine according to claim 3, **characterized** in that said second layer is connected to a predetermined potential.

5. A rotating machine according to claim 4, **characterized** in that said predetermined potential is ground potential.

6. A rotating machine according to any one of the preceding claims, **characterized** in that at least two adjacent layers have substantially equal thermal expansion coefficients.

7. A rotating machine according to any one of the preceding claims, **characterized** in that said current-carrying conductor (2) comprises a number of strands (18), only a minority of said strands being uninsulated from each other.

8. A rotating machine according to any one of the preceding claims, **characterized** in that each of said three layers (3,4,5) is solidly connected to the adjacent layer along substantially the whole connecting surface.

9. A rotating electric machine having a magnetic circuit for high voltage comprising a magnetic core and a winding, **characterized** in that said winding is formed of a cable (1;11) comprising at least one current-carrying conductor (2), that each conductor comprises a number of strands (18), that an inner semiconducting layer (3) is provided around each conductor, that an insulating layer (4) of solid insulating material is provided around said inner semiconducting layer, and that an outer semiconducting layer (5) is provided around said insulating layer.

10. A rotating electric machine according to claim 9, **characterized** in that it comprises a stator (8) and a rotor (7;37;47).

11. A rotating electric machine according to claim 10, **characterized** in that the stator comprises a laminated core (8) provided with winding slots (10) and that said winding is arranged in said slots.

12. A rotating electric machine according to any one of the preceding claims, **characterized** in that said cable also comprises a metal shield and a sheath.

13. A rotating electric machine according to any one of claims 1-8, 10-12, **characterized** in that the rotor (7) comprises salient poles (20).

14. A rotating electric machine according to claim 13, **characterized** in that the rotor includes strip coils.

15. A rotating electric machine according to claim 13, **characterized** in that the rotor includes wire coils.

16. A rotating electric machine according to claim 13, **characterized** in that the rotor is provided with a damper winding (27).

17. A rotating electric machine according to claim 13, **characterized** in that the poles are laminated poles.

18. A rotating electric machine according to claim 13, **characterized** in that the poles are solid poles.

19. A rotating electric machine according to claim 13, **characterized** in that the poles are mounted on the rotor by means of bolts.

20. A rotating electric machine according to claim 13, **characterized** in that the poles which are mounted on the rotor by means of a dovetail arrangement.

21. A rotating electric machine according to claim 13, **characterized** in that the rotor includes a rotor rim made of thin steel sheet.

22. A rotating electric machine according to claim 13, **characterized** in that the rotor includes a rotor rim made of thick steel plate.

23. A rotating electric machine according to claim 13, **characterized** in that the rotor includes a rotor rim made of solid steel.

24. A rotating electric machine according to claim 13, **characterized** in that the rotor includes an armature spider,

and that the poles and said armature spider are made in one piece and with pole shoes bolted to the poles.

25. A rotating electric machine according to claim 13, **characterized** in that the rotor is provided with an armature spider, a shaft and bearings.

26. A rotating electric machine according to claim 13, **characterized** in that the rotor is provided with a shaft and that the poles are provided directly on said shaft.

27. A rotating electric machine according to any one of claims 1-8, 10-12, **characterized** in that the rotor is a turbo type rotor (37).

28. A rotating electric machine according to claim 27, **characterized** in that the rotor includes a shaft (32) and a body and that said shaft and said body are forged.

29. A rotating electric machine according to claim 27, **characterized** in that the rotor includes a body and that said body is provided with winding slots (35).

30. A rotating electric machine according to claim 27, **characterized** in that the rotor is provided with a winding made of copper strips.

31. A rotating electric machine according to claim 27, **characterized** in that the rotor is provided with a winding and that said rotor is designed with a direct ventilation of said winding.

32. A rotating electric machine according to claim 27, **characterized** in that the rotor is provided with a winding and that said rotor is designed with an indirect ventilation of said winding.

33. A rotating electric machine according to claim 27, **characterized** in that the rotor is provided with grooves for a cooling medium.

34. A rotating electric machine according to claim 27, **characterized** in that the rotor is provided with ventilation ducts.

35. A rotating electric machine according to claim 27, **characterized** in that the rotor is provided with bearings.

36. A rotating electric machine according to any one of claims 1-8, 10-12, **characterized** in that the rotor is a cylindric rotor (47).

37. A rotating electric machine according to claim 36, **characterized** in that the rotor is made of laminated steel sheet compressed by means of steel rings.

38. A rotating electric machine according to claim 36, **characterized** in that the rotor is provided with a three-phase winding.

39. A rotating electric machine according to claim 38, **characterized** in that the winding is a diamond winding.

40. A rotating electric machine according to claim 38, **characterized** in that the winding is a bar winding.

41. A rotating electric machine according to claim 38, **characterized** in that the winding is a flat winding.

42. A rotating electric machine according to claim 36, **characterized** in that the rotor is provided with a single-phase winding.

43. A rotating electric machine according to claim 42, **characterized** in that the winding is a flat winding.

44. A rotating electric machine according to claim 42, **characterized** in that the winding is a diamond winding.

45. A rotating electric machine according to claim 36, **characterized** in that the rotor is provided with a damper winding.

46. A rotating electric machine according to claim 36, **characterized** in that the rotor is provided with a squirrel cage winding made of aluminium.

47. A rotating electric machine according to claim 36, **characterized** in that the rotor is provided with a squirrel cage winding made of copper.

48. A rotating electric machine according to claim 36, **characterized** in that the rotor is provided with a squirrel cage winding made of brass.

49. A rotating electric machine according to claim 36, **characterized** in that the rotor is provided with an armature spider.

50. A rotating electric machine according to claim 36, **characterized** in that the rotor is provided with a shaft (42).

51. A rotating electric machine according to claim 36, **characterized** in that the rotor is provided with bearings.

52. A rotating electric machine according to any one of claims 1-8, 10-51, **characterized** in that the rotor is designed for horizontal mounting.

53. A rotating electric machine according to any one of claims 1-8, 10-51, **characterized** in that the rotor is designed for vertical mounting.

54. A rotating electric machine according to any one of claims 1-8, 10-53, **characterized** in that the rotor is provided with slip rings.

55. A rotating electric machine according to any one of claims 1-8, 10-53, **characterized** in that the rotor is provided with a brushless exciter.

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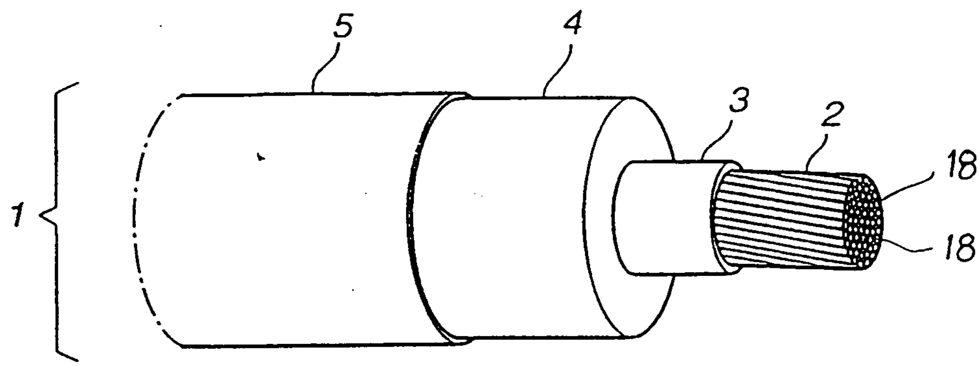

Fig. 1

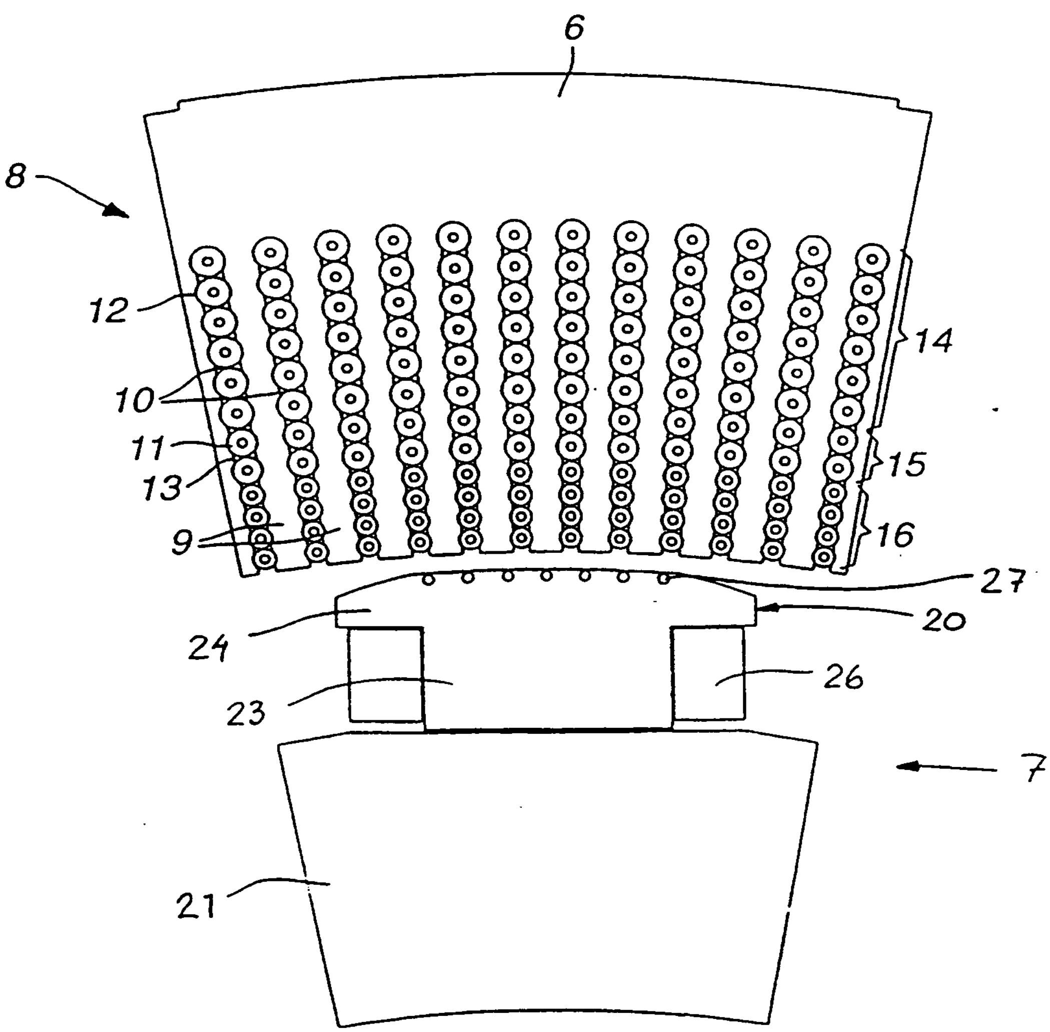

Fig. 2

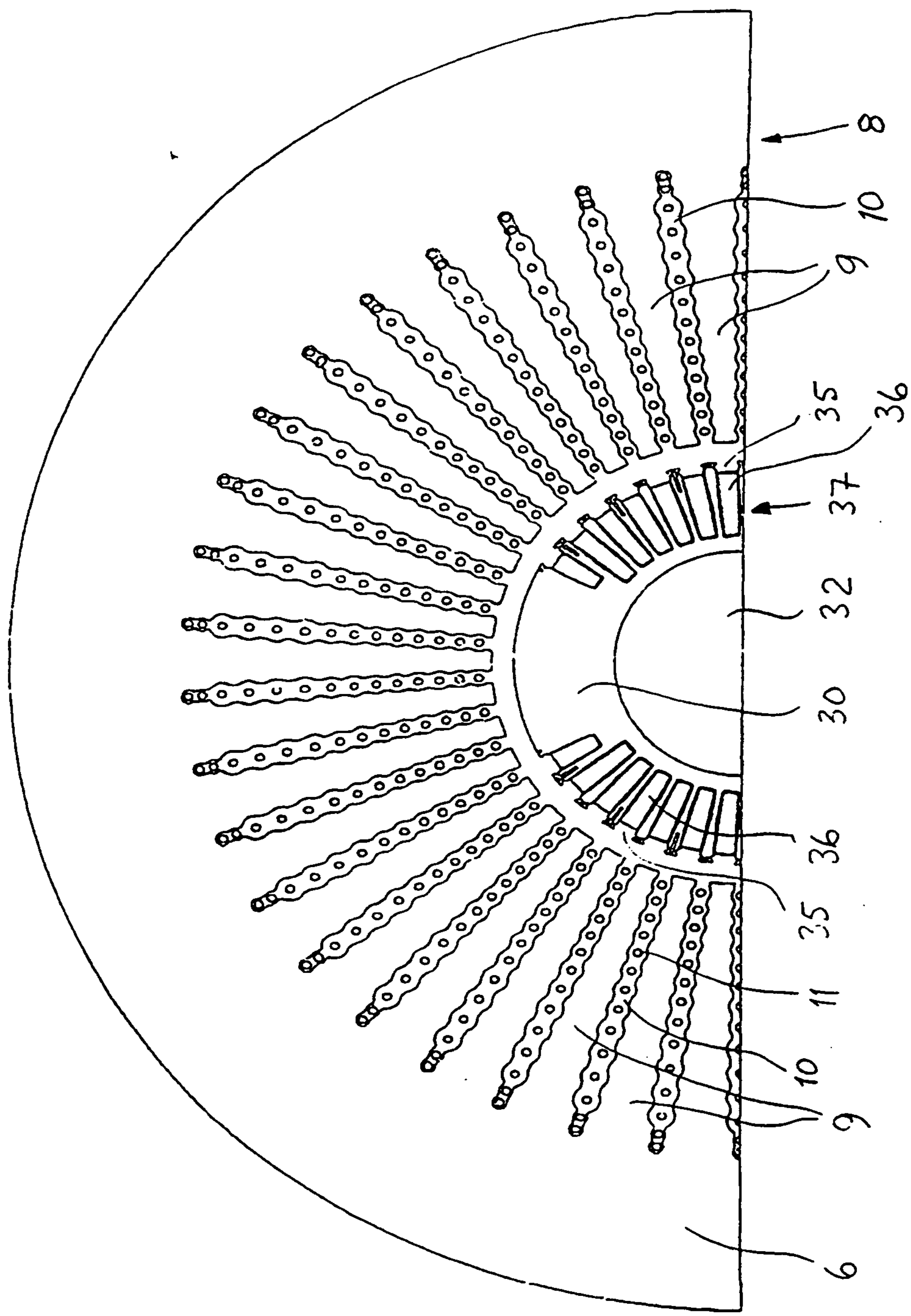

FIG: 3

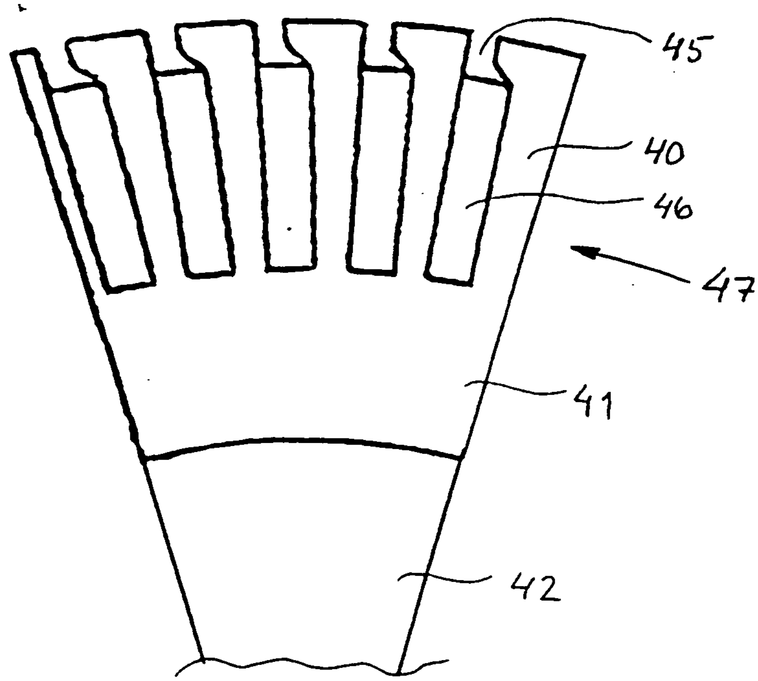

FIG: 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00892

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02K 3/40, H02K 15/08
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5036165 A (R.K.ELTON ET AL), 30 July 1991 (30.07.91), see the whole document --	1-55
A	US 4429244 A (P.Z.NIKITIN ET AL), 31 January 1984 (31.01.84), column 1, line 14 - line 29 --	1-55
A	CH 657482 A5 (K.VONES,GRAZ), 29 August 1986 (29.08.86), abstract --	1-55
A	US 4091139 A (J.F.QUIRK), 23 May 1978 (23.05.78), abstract --	1-55

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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Date of the actual completion of the international search	Date of mailing f the international search report
22 Sept 1997	26 -09- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Anders Axberger Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00892

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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